Effects of self-controlled feedback on learning of a throwing task in children with spastic hemiplegic cerebral palsy

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A B S T R A C T

The purpose of this study was to examine the effect of self-controlled feedback on learning a throwing task in children with spastic hemiplegic cerebral palsy (SHCP). In order to achieve the research objectives, using a semi-experimental method, 20 children with SHCP (7–12 years old) were selected from special schools in Tehran, Iran. After showing the participants how to do the throwing task, a pre-test with 10 trials was conducted to homogenize the participants. Then, they were randomly assigned to two groups (self-control group and yoked group) to be examined in acquisition, retention, and transfer phases. Children in self-control group requested feedback when necessary during the acquisition phase. In contrast, participants in yoked-group replicated the feedback schedules of their counterparts in self-control group without any choice. A multivariate analysis of variance (MANOVA) was performed to analyze the data. Based on the results, a significant difference was not found between the self-control and yoked-group in acquisition phase ($F = 0.538, p < 0.473$). However, there was a significant difference between the two groups in retention ($F = 11.72, p < .003$) and transfer ($F = 6.74, p < .018$) phases. Thus, based on the better results obtained in the self-control condition, this type of feedback can be used in physiotherapy programs related to children with CP to improve their motor skills and independence movements.

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1. Introduction:

For over a century, researchers and practitioners have been interested in determining ways to improve motor learning (Adams, 1987); relative frequency of augmented feedback is one of the challenges in this field. Research on augmented feedback showed that more feedback frequencies would cause destructive results (Young & Schmidt, 1992). The participants who received feedback after every trial displayed poorer performance in comparison with those who reduced their feedback frequencies regularly (Rice & Hernandez, 2006). The effects of knowledge of result (KR) on motor learning are known as guidance hypothesis (Salmoni, Schmidt, & Walter, 1984). Despite its strong effect, feedback frequency has three negative effects including information processing impairment, movement stability reduction, and feedback dependency (Salmoni et al., 1984). Some of the researchers, however, disagreed with the guidance hypothesis believing that higher feedback frequencies were required to learn complex skills due to a high need for control, attention, and memory processes (Wulf, Shea, & Matschiner, 1998). This hypothesis could not also explain the interaction between feedback frequency and type of attention-focus (Wulf, Mc Connel, Gartner, & Schwarz, 2002). On the other hand, many

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studies confirmed this hypothesis (Butki & Hoffman, 2003; Salmoni et al., 1984; Schmidt, Young, Swinnen, & Shapiro, 1989; Wulf & Schmidt, 1996) and introduced several techniques including summary feedback, average feedback, bandwidth feedback, and self-controlled feedback to prevent the negative effects of the feedback frequency mentioned above.

One of the experimental approaches used to provide feedback was self-controlled feedback which was used in settings where participants requested it themselves. In this specific type of feedback, participants were allowed to determine exercise features actively (Chiviacowsky and Wulf, 2005; Chiviacowsky, Wulf, Laroque de Medeiros, Kafer, & Wally, 2008). Studies related to the self-controlled feedback were conducted in settings in which self-control group was compared with another group called Yoked-group. Yoked control was widely used as a control technique that would allow controlling for the possible influence of the temporal relationship between an event and a response. Harmatz and Lapuc (1968) applied yoked-control technique to ensure that the control participants would receive the same number, spacing, and reinforcement as the experimental participants. Since participants in the yoked condition replicated the feedback schedule of their counterparts in self-control condition without any choice in receiving feedback, self-control group could have more learning advantages compared to the other group (Wulf, 2007).

Considering the assumption of this researcher about the effectiveness of reduced feedback frequency, the question arisen here is ‘which methods of providing feedback (self-control or yoked control) would be more effective in motor learning’. Recent studies by Chiviacowsky and Wulf (2002, 2005, 2007) have been more concerned with self-controlled feedback than other types. Wulf and Toole (1999) suggested that self-controlled feedback would encourage participants to discover more strategies.

Although many studies have examined the effects of feedback on motor learning, these studies have mainly focused on adults, and typically developing (TD) individuals; however, few studies have examined the role of feedback in individuals with physical difficulties such as cerebral palsy (CP). CP is a congenital neurological disorder and the possibility of its occurrence is from conception to two years after birth. Spastic hemiplegic cerebral palsy (SHCP) is one of the most common forms of CP caused by unilateral damage to the motor cortex or pyramidal pathway. Unilateral muscles in the other side of the body (with respect to the damaged brain) are affected by spasms and cramps, and proprioceptions in the affected organs are impaired. As a result of these changes, movements in the affected side become slow, jerky, and alternative (14). The results of studies on the individuals with CP showed that they were able to learn motor skills. For example, Hemayattalab and Rashidi Rostami (2010) studied the learning of a new motor skill in individuals with CP and concluded that they could learn the skill of throwing dart (12). Effects of task context and lack of prediction planning was examined by Mutsaarts, Steenbergen, and Bekkering (2006) in individuals with hemiplegic cerebral palsy (HCP). The results showed that lack of prediction planning in the participants with CP had been caused by the impairment in motor imagery; as an alternative strategy, they used information directly available in the task context. Based on this finding, individuals with CP had deficiency in motion planning of the central nervous system (CNS) as well as dysfunction in the muscular system (Mutsaarts et al., 2006). Therefore, learning a new motor skill might be challenging to them.

Studies on the self-controlled feedback in children have yielded contradictory results. For example, Chiviacowsky and Wulf (2008) carried out two studies on children. In the first study, the results related to the older people were generalized to the children; in the second, the effectiveness of self-controlled feedback with more frequencies was shown.

Furthermore, few studies have examined the effects of feedback in individuals with CP. Interesting results, though, have been obtained. For example, Hemayattalab and Rashidi Rostami (2010) concluded that principles related to the feedback frequency in individuals with CP were similar to TD people; higher feedback frequencies had more feedback dependency. In another study by Harbourne (2001), the effects of KR on the upper limbs ability were examined in two groups including 10 healthy adults and 10 adults with CP to detect target speed and identify the possible error. The effects of KR on individuals with CP were found to be the same for TD people in this study. However, there was not enough evidence and further research is required.

Based on the literature, no study has yet compared self-control and yoked feedbacks in individuals with CP. Accordingly, in the present study there was an attempt to address this issue. For this purpose, two methods of providing feedback were considered in which the participants in self-control group could request feedback when they wanted to, while participants in yoked-group replicated the feedback schedules of their counterparts in self-control group without any choice. Thus, it was expected that by comparing two feedback conditions in children with SHCP, the researchers would be able to answer this question: which method of providing feedback (self-controlled feedback and yoked feedback) would be more effective?

2. Materials and methods

2.1. Participants

The study population consisted of 20 children with cerebral palsy (CP) who were recruited from a special school for the disabled children in Tehran, Iran. The inclusion criteria were being male and diagnosed with spastic hemiplegic cerebral palsy (SHCP), without intellectual disabilities and aged between 7 and 12 (M = 11.6 years, SD = 1.5). Hand dominance was determined by asking participants which hand they used for writing; participants were asked to use their non-dominant arm to throw the bean bags toward the target. Participants with right-hand dominance were 12 (60%), and those with left-hand 8 (40%). The exclusion criteria were sufferance from neurodegenerative diseases, psychiatric illness, traumatic head injury, epilepsy, hearing and visual impairment, and moderate to profound mental retardation that would interfere with their
ability to perform the task. Also, the severity and topography of motor disability were classified by physical therapists in department of rehabilitation using Gross Motor Function Classification System (GMFCS) (Palisano et al., 2000). GMFCS is a five-level classification system that describes the gross motor function of children with CP on the basis of their self-initiated movement with particular emphasis on sitting, walking, and wheeled mobility. Individuals at levels I to III could achieve self-mobility without using a powered wheelchair (Palisano et al., 1997) so they were recruited in this study; Individuals at levels IV and V (representing moderate to severe limitations in motor controls) could not perform the required movements and were excluded. Type of CP and diagnosis were determined by pediatric orthopedicians and rehabilitation medicine physicians. There was no difference in ethnicity between the two groups of children with CP; they were all Iranian. None of the participants had previous experience with the task and were naive to the purpose of the experiments. Written informed consents were obtained from either the parents or the guardians of all participants prior to the study. They were also informed that the data gathered in this study would be kept completely private. The study was approved by the institutional review board of the university.

2.2. Apparatus and procedure

The task used in this study was similar to the one used by Chiviacowsky, Wulf, Laroque de Medeiros, and Kaefer (2006). Participants were asked to throw bean bags (100 g) overhead. They stood behind a line while throwing beanbags toward a circular target with a 10 cm radius located 3 m away from them. The accuracy of throwing was assessed by concentric circles with radii of 20, 30, and 40 up to 100 cm drawn around the target. In acquisition phase (including 80 trials), participants could not see the target area because they wore an opaque swimming goggle. Scores were given based on the landing site: if bean bag was in the center of the target, point 100; outside of the target, point 0; and other areas of the target, point 90, 80, 70, etc. were given, respectively. If it landed on the line, the higher score was recorded. The target area was divided into four quadrants. Information about the trials including “long”, “short”, “left”, or “right” were given to the participants, indicating where the bean bag was landed (see Fig. B.1). In addition, the experimenter indicated whether the toss was “near” (Zones 60–90) or “far” (Zones 0–50) from the target. Participants in self-control group could request feedback whenever they needed, while participants in yoked group replicated feedback schedules of their counterparts in the other group without any choice. Acquisition phase (10 trials–without feedback) was immediately conducted after the last session of the practice; Retention and transfer phases were conducted 24 h after the acquisition phase. These phases consisted of 10 trials and participants could not see the target area. But in the transfer phase, the distance from the target was higher compared to the retention phase (4 m vs. 3 m).

2.3. Data analysis

Descriptive and inferential statistics were used to analyze the data. Central and dispersion parameters of the experimental groups were calculated in descriptive statistic. A multivariate analysis of variance (MANOVA) was performed to analyze the results. An alpha level of .05 was used for all statistical tests. Statistical analysis was conducted using SPSS 16.

3. Results

Descriptive statistics related to the two experimental groups are presented in Table A.1. There were no significant differences in age, height, and body weight between the two groups of children with spastic hemiplegic cerebral palsy (SHCP).

Based on the results of Kolmogorov–Smirnov (k–s) test, the data distribution in pre-test phase was normal and there was not a significant difference between demographic variables.

Fig. B.1 shows the mean scores related to the throwing task in the pre-test, acquisition, retention, and transfer phases in children with SHCP. As shown in Fig. B.1, both groups improved the accuracy of their tosses from the beginning to the end of the practice phase. Although both groups had relatively similar scores in the acquisition phase, there was a difference between the two groups in retention and transfer phases with the self-controlled feedback group getting higher scores.

One of the assumptions for MANOVA is the equality of variance/covariance matrices of the different analyzed groups. The multivariate test for homogeneity of dispersion matrices showed that observed covariance matrices of the dependent variables across groups were the same (p = .238). The results of the MANOVA test revealed that ‘group’ had a significant effect (Wilks’ Lambda = 0.542, F(3, 16) = 4.513, p = 0.018).

As shown in Table A.2, based on the results of MANOVA, a significant difference was not observed to exist between the self-control and yoked-group in the acquisition phase (F = .538, p < .473). However, the results showed a significant difference between the two groups in retention (F = 11.72, p < .003) and transfer (F = 6.74, p < .018) phases.

4. Discussion

Effects of knowledge of result (KR) (Young & Schmidt, 1992), and also self-controlled feedback (Janelle, Barba, Frehlich, Tennant, & Caurbaugh, 1997) have been proved on motor learning. Most researchers have examined feedback effects on typically developing (TD) individuals; it is important to understand whether diverse populations respond in a similar way or not. Therefore, the present study was performed to examine the effects of self-controlled feedback on learning
a throwing task in children with spastic hemiplegic cerebral palsy (SHCP). The results did not show a significant difference between self-control and yoked conditions in the acquisition phase. Consistent with the findings of Chiviacowsky and Wulf (2006), self-control phenomenon could be explained from both cognitive and motivational perspectives. In fact, there was an inverse relationship between cognitive and motivational processes. From a motivational perspective, factors such as setting goal, requesting feedback when they want, and having more independence led to higher levels of intrinsic motivation and more effort in the learning process in the self-control condition. From a cognitive perspective, however, self-control condition was followed by more pressure on learners because the learning process should be decided based on the learner’s own knowledge of the task, what time and how they request feedback, how many times they need to choose feedback, and eventually, when and to what extent they should change task difficulties. Therefore, in the present study, the contradictory effects of cognitive and motivational processes led to a similar performance between self-control and yoked groups in the acquisition phase. According to the findings, there was a significant difference between the two groups in both retention and transfer phases; children with control on feedback request (self-control group) showed more effective learning than those without control on it (yoked-group). These results were consistent with the previous studies that showed the effectiveness of self-controlled feedback in retention phase (Chiviacowsky et al., 2008; Wulf, Raupach, & Pfeiffer, 2005). Also, the present findings were in agreement with the prediction of challenge point framework (CPF) suggesting that an interaction between task outcomes, characteristics of learners, and exercise conditions would change the level of individual’s involvement during exercise. Maximum benefit of exercise for learning would occur in an optimized challenge point. If challenges were more than the optimized challenge point, the result would be an increase in cognitive effort more than the information processing capability and, consequently, a decrease in learning benefits. According to the CPF results, if the bean bags task used in this study leads to a higher challenge, the participants in the self-control condition organize their training requirements to reach an optimized challenge point. Based on this finding, self-controlled feedback is considered as a suitable approach to examine the predictions of CPF because children in this group could match their needs with exercise requirements (Chiviacowsky & Wulf, 2002; Janelle et al., 1997). Several factors seemed to be involved in effectiveness of the self-control conditions compared to the yoked conditions in retention test. It is suggested that giving the opportunity of control over practice regime leads to a deeper information processing (Chen, Hendrick, & Lidor, 2002), higher level of motivation (Bandura, 2001), greater use of self-control strategies (Kirschenbaum, 1984), and eventually more responsibility for the learning process (e.g., Ferrari, 1996) in children. Some studies showed that people affected by the central nervous system (CNS) disorders would respond to feedback in the same way as TD people. For example, Hemayattalab and Rashidi Rostami (2010) found that the principles related to the feedback frequency were similar in children with CP. Interestingly, the present results showed the same principles related to the self-controlled feedback in children with SHCP. Based on the findings, it is suggested that request of feedback in self-control conditions will be more effective in adjusting to the needs and preferences of CP individuals. The positive effects of self-controlled feedback could also be used for using assistive devices in individuals with physical disabilities such as CP. For example, Wulf, Clauss, Shea, and Whitacre (2001) demonstrated that motor learning would be made more effective by allowing participants to choose an appropriate time for using assistive devices in a ski-simulator task. They believed that these devices were used when participants were either afraid of falling or interested to test movement strategies in a safe condition before performing the task without physical assistance. Findings from this investigation would have important theoretical and practical implications for physiotherapists in rehabilitation settings. Motor skills were more vulnerable in the non-dominant part of the body in children with SHCP; these individuals often used the less affected side of their bodies (Winnie & Dunn, 2000). According to the studies on spasticity, range-of-motion restriction and muscle weakness were more common in non-dominant side of the body in individuals with SHCP. Since the dominant side had less spasticity because of excessive use, performing more physical activity with the non-dominant side would increase coordination and fluency in the affected limbs of these individuals.

However, the number of participants during this study was limited to 20, ranged between 7 and 12 years which might not be sufficient for the best results. Furthermore, participants were all individuals suffering from SHCP, so these results are not generalizable to other groups of CP.

5. Conclusion

If results from this study are corroborated, the therapists would be prepared to create settings in which individuals with spastic hemiplegic cerebral palsy (SHCP) could improve their motor skills and independence as quickly and effectively as possible.

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Appendix A. Statistical analyses tables

See Tables A.1 and A.2.
Appendix B. Statistical analyses figures

See Figs. B.1–B.3.

Fig. B.1. Schematic of the target area and zones used to provide feedback (e.g., “long, near”).

Fig. B.2. Performance graph in pre-test, acquisition, retention, and transfer phases in two groups of children with spastic hemiplegic cerebral palsy (SHCP).
Fig. B.3. Means of throwing in pre-test, acquisition, retention, and transfer phase in two groups (self-controlled and yoked group) of children with spastic hemiplegic cerebral palsy (SHCP).

References


